IFIP WORKING GROUP 7.6 WORKSHOP o
VIRTUAL ENVIRONMENTS for ADVANCED MODELING
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Loosely Coupled Components Working Group

Operations Research Department
Naval Postgraduate School, Monterey, CA

Sponsors

Air Force Office of Scientific Research
Office of Naval Research
US Special Operations Command
Defense Advanced Research
Projects Agency
Institute for Joint Warfare Analysis
TRADOC Analysis Center – Monterey

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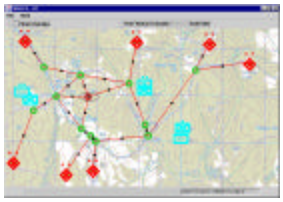


Dynamic composition

of systems that are
platform independent, dynamic, and
distributed over a dynamic computer network
using **Loosely Coupled Components**

Analysis in the decision cycle

Analysts in the loop

Motivation

Joint Vision 2010 (2020)	Internet
Special Operations Forces Vision 2020	Object oriented
Army XXI, Army After Next	Java
New World Vistas (USAF)	
Network Centric Warfare (Navy After Next)	

Some Goals
Information superiority to achieve dominate battlespace awareness
Speed of command to replaces attrition
Increased temp of execution through faster planning
Overwhelming early effort to lock out adversary's courses of action

Environment

Major Theater War, Small Scale Contingencies, Peacekeeping

Joint, coalition, interagency, international organizations,
private organizations

Dynamic distributed computing devices
Wired and wireless
Large number of sensors
Huge collections of raw data
Decision makers at all levels

Critical Features
Unexpected missions
Shorter time lines
Data glut

Operations Research Contribution
Construct decision support systems
to convert data into information for decision makers

Goal
Dynamic composition of systems that are
platform independent, dynamic, and distributed
over a dynamic computer network

Need for Component Architecture

- Cannot build systems in near real-time from scratch
- Must use pre-built building blocks
- Low-level "components" too fine-grained
- High-level "components" too rigid

"System of Systems"

- Connect legacy systems to create new systems
- Essentially, the legacy system acts as a Component
- Cannot be used dynamically
  - Systems have their own, fundamentally incompatible World View
  - Systems have not been designed for interoperability

Necessary … But Not Sufficient

- Components alone
- Object-Oriented Design
- Java
- World Wide Web
- Platform independence

Map-Based Planning Domain

- We need Components to perform tasks such as:
  - Display maps, satellite images, overlays,
  - Access, enter, and modify data,
  - Construct and display models of military operations, and
  - Access and execute algorithms to analyze operations.
- There are many possible combinations of displays, data, models, and algorithms
- We don't know in advance which systems we will need,
  - Construct the components and then construct systems rapidly as the need emerges (perhaps on the fly).
- Building systems out of components is not sufficient.
- Components must be coupled in a "loose" fashion.

Fundamental Questions

- Application Question
  - How do we build systems to support real-time and near real-time decision support?
- Research Question
  - What Component Architectures are sufficient to perform dynamic composition?

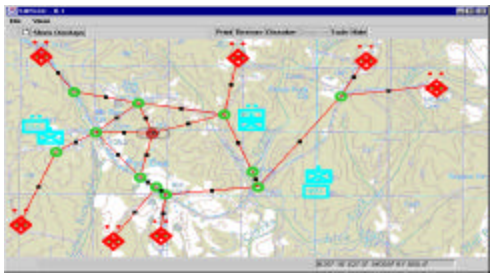
Demonstration systems

'proof of concept' systems and student theses

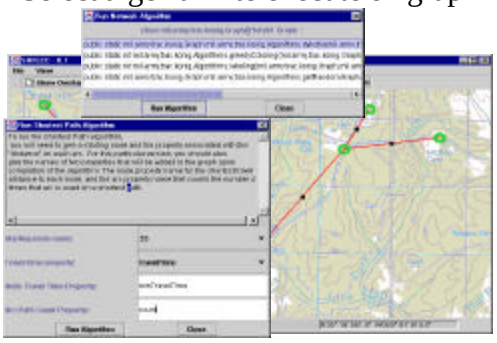
Using the LCCWG map-based planning components, officer-students as part of their thesis research have constructed demonstration systems for the following notional scenarios:

1. Special forces attack on a radar site in Bosnia,
2. Civilian search and rescue with Bayesian updates,
3. UN convoy operations in Bosnia,
4. Special Operations (Ranger) mission planning and analysis,
5. Ranger air load planning,
6. Wireless computer network Ranger air field operations,
7. Tracking Marine Corps training with GPS devices,
8. SOF Tactical Intranet using COTS Wireless Network, and
9. Solving battlespace movement problems using dynamic, distributed computer networks.

"Concept for a Special Operations Planning and Analysis System," 1998
MAJ Allan L. Bilyeu , USA

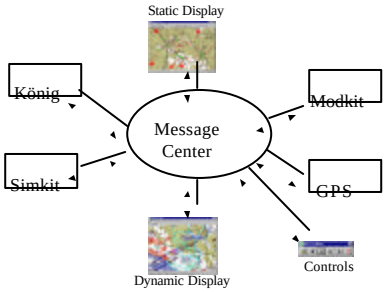


Select algorithm to execute on graph

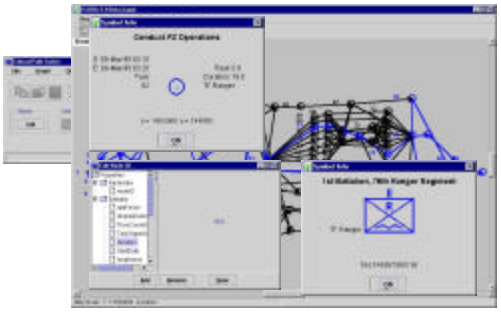


"Visual Planning Aid for Movement of Ground Forces in Operations Other Than War," 1999
CPT Norbert Schrepf, German Army

Message Center

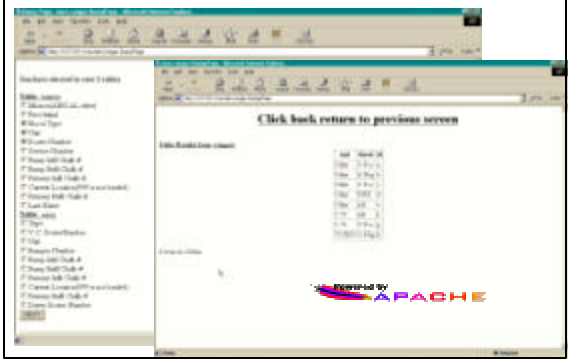


"Special Operations Mission Planning and Analysis Support System," 1999
CPT Keith A. Hattes , USA



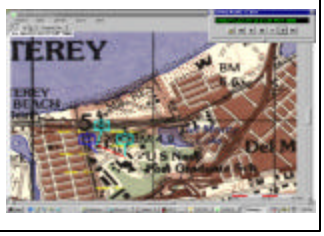
"Ranger Air Load Planner," 2000
CPT Maximo A. Moore, III, USA

"Wireless DACO Board," 2000
CPT Maximo A. Moore, III, USA



"Tactical Exercise Review and Evaluation System," 1999
Major David P. Krizov , USMC

Playback
- Event step Animation
- Interactions graphically portrayed
  - Direct fire by arrows
  - Indirect by stars
- Dynamic display uses VCR controls



Additional Work

"SOF Tactical Intranet: Low Probability of Detection, Low Probability of Exploitation Communications for Special Operations Forces, Using A Commercial Off The Shelf Wireless Local Area Network," 1999
LT Robert B. Moss, USN

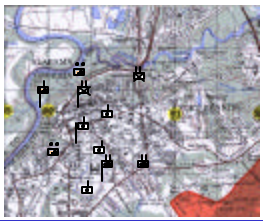
"An Airborne High Data Rate and Low Cost Digital Communications Network Using Commercial Off The Shelf Wireless Local Area Network Components," 1999
LT Stephen J. Tripp, USN

"Solving Dynamic Battlespace Movement Problems Using Dynamic Distributed Computer Networks," 2000
CPT Robert D. Bradford, III, USA

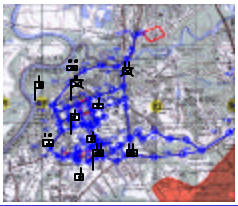
A Specific System

- Dynamic battlefield
- Moving Units
- Changing status of road network
- Where is the closest aid station?

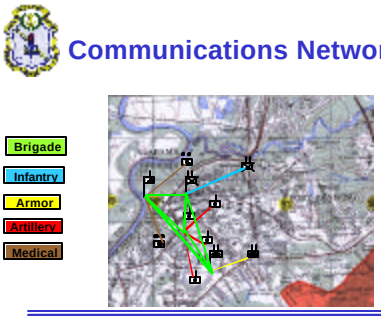
Units



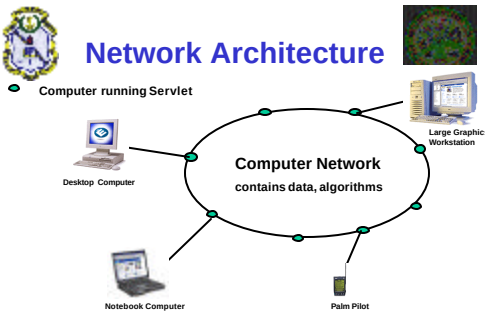
Road Network

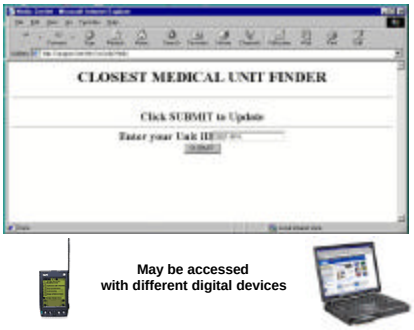


Communications Network



Network Architecture





May be accessed
with different digital devices

Marshal resources

Model - network
Data - road network
- unit locations
Algorithm - shortest path

Construct model

Select solution computer

Extract solution

Construct appropriate view of solution

Serve solution

Map view solution

Other Applications of MRMO

- **Division movement from Port of Debarkation to Forward Battle Area**
- **Movement of ammunition resupply convoys**
- **Stability and Support operations Humanitarian Relief Convoys**
- **Network Interdiction and Protection**

Frameworks

- König – Graph and network models with orthogonal structure and generic properties
- Simkit – Component-based discrete event simulation
- Thistle – Generic messaging/maps and overlays
- Modkit – Recursive delegation/dynamic acquisition of properties

Dynamic Composition of Systems Using Principles of Loosely Coupled Components

- Strict Separation of Components
  - Model-View-Controller
- Dynamic Loading
  - Self-describing classes
  - Discovery of actions
- Generic Data
  - Property names as Strings
  - Values as Objects

Dynamic Composition of Systems Using Principles of Loosely Coupled Components

- Dynamic Acquisition of Properties
  - Recursive Delegation
- Dynamic Message Dispatching
  - Message Center
- Decoupling Algorithms from Data Structures
- Components need to be as orthogonal as possible
  - Maps and Overlays are two "View" Components

Ongoing Work

- Continue to define Component Architecture to support Dynamic Composition
- Absorb new and emerging technologies
  - XML
  - JINI/Javaspaces
  - Enterprise Java
- Adopt any technology that does not compromise the ability to do Dynamic Composition

Dynamic Composition

the most important problem in Operations Research